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WEST FORK RIVER INVESTIGATION. MONETARY
BENEFITS TO POLLUTION ABATEMENT BY FLOW
REGULATION FROM WEST FORK RESERVOIR,
BROWNSVILLE, WEST VIRGINIA

M. LeBosquet, Jr.

Public Health Service
Cincinnati, Ohio

December 1947

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Monetary Benefits to Pollution Abatement
by Flow Regulation from West Fork Reservoir
Brownsville, West Virginia

U. S. Public Health Service
Sanitary Engineering Division
Water & Sanitation Investigations
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Brownsville, West Virginia

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Prepared by the U. S. Public Health Service
at the request of and in co-operation with the
District Engineer, United States Engineer Office
Pittsburgh, Pa.

I

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III

Introduction

Under date of 19 August 1947, the District Engineer, U. S. Engineer Office, Pittsburgh, Pa., requested that the U. S. Public Health Service determine the magnitude and nature of low-water regulation benefits to pollution abatement from a proposed reservoir on West Fork River to be located at Brownsville, a few miles above Weston, West Virginia. The request that the work would be done on a reimbursable basis, with all expenses for personal services and travel being paid by the District Engineer, Pittsburgh, Pa.

The present investigation has been confined largely to the question of pollution abatement, leaving to the U. S. Engineer Office any benefits to West Fork River water supplies, both municipal and industrial, resulting from increased flow in West Fork River. However, benefits to public and industrial water supplies in the Monongahela River due to improved quality resulting from the increased flow, have been included in the present investigation.

Studies of the West Fork River Basin were conducted in 1940 at the time of the Ohio River Pollution Survey, and the report on this work is available in House Document 266, 78th Congress, 1st Session, page 355, Monongahela River Basin.

Laboratory results on stream water samples collected during May and June, 1940, which form an important basis for the present report, are published on pages 375 to 380 of the above report and are not reproduced herein.

Under date of September 8, 1947, a preliminary letter report was submitted, setting forth tentative estimates of benefits from the proposed reservoir. Later, under date of October 1, 1947, a supplementary memorandum was submitted, setting forth the desirable seasonal flows to be provided below Weston and Clarksburg, W. Va.

The investigation has been carried on with the close cooperation and assistance of the Pittsburgh District Engineer Office, and that office has furnished detailed hydrometric data and has assisted in other phases of the work.

Data on the reservoir under consideration at the present time are given in Table 1.

Conclusions

(1) Sewage and minor industrial wastes from a sewered population equivalent of 47,700 are discharged in the West Fork River Basin. Treatment of sewage in two small municipal sewage treatment plants and treatment of industrial wastes in one small plant reduces this pollution load from 47,700 to 45,600 sewered population equivalent, a reduction of less than 5 per cent.

(2) Acid mine drainage, prior to the mine-sealing program, discharged an estimated 86,700 tons of acid per year in the West Fork Basin. Acid mine drainage is discharged largely in the lower reaches of the basin. The mine-sealing program reduced the acid load from 1933 to 1940 to an estimated 50,500 tons per year. Lack of maintenance has probably reduced the effectiveness of the sealing program.

(3) The State of West Virginia, through actions against municipalities, through co-operation with the mine-sealing program, and through regulation of strip mining operations, has acted to correct present pollution and to prevent future growth of pollution.

(4) Useful flows for organic pollution abatement below Weston and Clarksburg, W. Va., are estimated as follows:

<u>Location</u>	<u>Winter Flow</u>	<u>Summer Flow</u>
Weston, W. Va.	60 c.f.s.	130 c.f.s.
Clarksburg, W. Va.	90 "	200 "

(5) Desirable increases in low flows in Monongahela River from West Fork River for acid control are limited only by the ability of West Fork Reservoir to supply such flows. In general, supplemental low flows should be provided to fill in low points in the Monongahela River hydrograph. Shorttime failures to provide proposed flows will have no significance in reducing acid control benefits, as no lasting damage will result.

Table 1 - West Fork River Investigation - Data on Proposed West Fork River Reservoir above Weston, W.Va.

Item	Unit	Quantity
Drainage area	Square miles	102
Areas:		
Minimum pool	Acres	200
Maximum summer pool	"	5,100
Reservoir full	"	5,800
Capacity:		
Minimum pool	Acre-feet	2,000
	Inches of runoff	0.4
Low-water regulation, winter	Acre-feet	120,000
	Inches of runoff	22.
" " " summer	Acre-feet	131,000
	Inches of runoff	24.
Flood control, winter	Acre-feet	38,000
	Inches of runoff	7.0
" " summer	Acre-feet	27,000
	Inches of runoff	5.0
Reservoir full (gross)	Acre-feet	160,000
	Inches of runoff	29.4

(6) Estimates of monetary value of pollution abatement benefits from proposed regulation, based on providing indicated flows in West Fork River and based on providing a low-flow increase of 200 c.f.s. in the lower rivers, total \$120,000 per year, divided as follows:

<u>Organic Pollution Abatement Benefit</u>	<u>Annual Value</u>
Below Weston, W. Va.	\$ 7,000
Below Clarksburg, W.Va.	43,000
Below Pittsburgh, Pa.	35,000
Below Cincinnati, Ohio	35,000
Total	<u>\$ 120,000</u>

(7) Estimates of monetary value of acid control benefits from proposed regulation total \$330,000 per year, divided as follows:

<u>Acid Control Benefit</u>	<u>Annual Value</u>
Monongahela River above McKeesport, Pa.	\$214,000
Monongahela River below McKeesport, Pa.	75,000
Ohio River	41,000
Total	<u>\$330,000</u>

Description

The West Fork River is about 93 miles long from its source at Waterville in Lewis County, W. Va., to its mouth at Fairmont, where it joins with Tygart River to form the Monongahela River. The principal tributaries of interest in connection with the present investigation are as follows:

<u>Tributary</u>	<u>Miles above West Fork River mouth</u>	<u>Drainage area, square miles</u>
West Fork River	--	882
Polk Creek	65	
Stone Coal Creek	65	
Heckers Creek	54	
Elk Creek	30	122
Limestone Run	30	
Simpson's Creek	21	
Tenmile Creek	18	

The principal cities in the West Fork Basin are Clarksburg and Weston, both located on the main West Fork River and both below the proposed reservoir site. These and other cities in the basin, with their 1940 U. S. Census populations, are as follows: Clarksburg 30,579, Weston 8,268, Shinnston 2,817, Salem 2,571, Nutter Fort 1,803, Bridgeport 1,581.

The coal mining industry is of chief importance in the basin. The current trend is to expand the mining of coal through stripping operations. While the detrimental effect of acid mine drainage is now confined largely to the lower parts of the basin and certain tributaries, the expansion of coal mining activities to the upper reaches of the river is a trend worthy of serious consideration in connection with water quality.

Survey Methods

In view of the fact that rather comprehensive data on the water pollution problem of the West Fork River Basin are already available in House Document 266, 78th Congress, 1st. session, a comprehensive field investigation of pollution problems was considered neither justified nor necessary for present purposes. The present investigation, therefore, has consisted primarily of the assembly, tabulation, presentation and study of existing information. A brief trip was taken through the basin for the prime purpose of determining possible recent developments or changes in the situation existing in 1940. Recent information on water quality was obtained from the various public water supplies treating surface waters. In addition, the State of West Virginia, during 1946, collected two series of samples in the Weston, W. Va., area, and one series of samples in the Clarksburg, W. Va., area. All of these samples were collected during times of extremely low flow.

Hydrometric data compiled by the District Engineer Office, both at the time of the Ohio River Pollution Survey and more recently, consisted of tabulations of monthly average flows, including the effect of the proposed West Fork River Reservoir at Brownsville on these flows.

Presentation of Data

Public Water Supplies

As indicated in Table 2, there are five public water supplies in the West Fork River Basin that are taken from river sources. These serve a population of 46,400 with 3,420,000 gallons daily. By far the largest supply in the basin is at Clarksburg, which supplies a population of 35,000 with 2,500,000 gallons daily.

During periods of extremely low flow, the natural discharge of West Fork River is none too large for the consumption, and should there be any substantial growth in the area, expanded water supply facilities will be required. The discharge of acid mine drainage has been a minor factor in the past, but present indications are that serious problems will be created in the future.

Table 2 - West Fork River Investigation - Public Water Supplies

Supply (West Virginia)	Mile (1)	Source	Treat- ment (2)	Popu- lation served	Consump- tion, MGD
<u>West Fork River</u>	-				
Dam site - West Fork R. Reservoir	73				
Weston St. Hosp.	66	West Fork River	FD	2,000	0.24
Weston	66	West Fork River	FD	8,200	.26
Jackson Mill	62	Impounded	FD	500	.03
Clarksburg (3)	31	West Fork River	FZD	35,000	2.30
Zeising (spelter)	21	West Fork River	FD	800	.01
Shinnston (4)	14	Impounded	FD	3,600	.20
Hutchinson	11	West Fork River (and spring)	FD	400	.01
Northington	9	Well (and spring)	D	400	.02
<u>Simpson Creek</u>	21				
Wendell	43	Well	None	1,000	.02
Galloway	41	Well	None	800	.02
Bridgeport	31	Impounded	FD	1,800	.05
<u>Ten Mile Creek</u>	18				
W.Va. Ind. School	41	Well	None	300	.02
Salem	41	Well	None	2,500	.05
Lumberport	19	Impounded	FD	1,000	.04
Subtotal	-	Wells	-	5,000	.13
"	-	Impounded	-	6,900	.32
"	-	River	-	46,400	3.42
Total	-	All sources	-	58,300	3.87

(1) Miles to mouth, West Fork River.

(2) F-Coagulated, settled, filtered; D-Chlorinated;
Z-Zeolite softened.

(3) Also serves Nutter Port and Pinnickinnick.

(4) Also serves Owin s and Gypsy.

8.

will be created in the future. The City of Shinnston recently found it necessary to bring legal action because of acid mine water pollution of its public water supply, taken from an impoundment on a tributary.

Sources of Pollution

Table 3 summarizes the location and magnitude of significant sources of pollution, largely domestic sewage discharged to streams in the West Fork River Basin. The total pollution load prior to treatment has a sewered population equivalent of 47,700, of which all but one minor industrial waste discharge is domestic sewage from municipal sewers. Two rather small sewage treatment plants in the basin reduce this total pollution load from 47,700 to 45,600, a reduction of less than 5 per cent.

Data on the acid mine pollution problem have been taken from the Ohio River Pollution Survey Report and also from the report on Sealing Abandoned Coal Mines project for West Virginia covering the period December 15, 1933, to June 30, 1939, prepared by the U. S. Public Health Service. These data are summarized in brief form in Table 4. According to the latter report, mine-sealing efficiency, or the reduction in acid by sealing, averaged in West Virginia about 70 per cent. Inasmuch as mines sealed in the basin originally produced 50,500 tons of acid per year, the reduction can therefore be estimated at 35,000 tons per year. This represents a reduction of 40 per cent in the total original acid load in the basin of 86,700 tons per year. The mine seals constructed between 1933 and 1939 have since received very little maintenance, and it may therefore be expected that the efficiency today is somewhat less than the 70 per cent on which the above estimate of reduction is based.

It is noted in the table that the amount of acid mine drainage, as of 1939, coming from Lewis County in the upper reaches of the West Fork River Basin, was relatively minor compared to the acid produced in the center and lower sections of the basin. While watershed lines do not conform well to county lines, it is believed that Table 4 presents a reasonably accurate picture of the acid mine drainage situation prior to recent strip mining operations.

Table 3 - West Fork River Investigation - Sources of Pollution Including Industrial Wastes Expressed as Sewered Population Equivalent (B.O.D.) Discharged to West Fork River and Its Tributaries.

Location (West Virginia)	Mile (1)	Population connected to sewers	Treat- ment (Sewage only)	Sewered popula- tion equivalent (B.O.D.)	
				Un- treated	Dis- charged
<u>West Fork River</u>	-				
Dam site - West Fork R. reservoir	73				
Weston St. Hosp.	66	2,000	Second- ary	2,000	300
Weston	66	5,000	None	5,000	5,000
Jackson Mill (2)	62	500	Pri- mary	500	300
Clarksburg	30.7	29,000	None	29,000	29,000
Zeising (spelter)	21	800	None	800	800
Shinnston	18	2,400	None	2,400	2,400
Worthington	9	400	None	400	400
Monongah	5	1,700	None	1,700	1,700
<u>Hackers Creek</u>	54.2				
Jane Lew	58	100	None	100	100
<u>Limestone Run</u>	30				
Wilsonburg (3)	32	-	-	300	100
<u>Elk Creek</u>	30				
Nutter Fork	34	1,700	None	1,700	1,700
<u>Simpson Creek</u>	21				
Flemington	39	100	None	100	100
Bridgeport	31	1,300	None	1,300	1,300
<u>Ten Mile Creek</u>					
W.V. Ind. Home	41	300	None	300	300
Salem	41	1,900	None	1,900	1,900
Lumberport	19	200	None	200	200
Total	-	47,400	-	47,700	45,600

(1) Miles to mouth, West Fork River

(2) 4-H camp

(3) Industrial waste treated.

Table 4 - West Fork River Investigation - Acid Mine Drainage

Data as of 1940	Counties			
	Marion 33%	harrison 100%	Lewis 100%	Total
Number of mines:				
Active	9	42	20	71
Marginal	2	16	8	26
Abandoned	19	120	36	175
Total	30	178	64	272
Sealed and in process	13	107	17	137
Tons acid per year:				
Active	5,500	20,300	100	25,900
Marginal	200	4,700	0	4,900
Abandoned	2,900	52,000	1,000	55,900
Total	8,600	77,000	1,100	86,700
Sealed and in process	2,700	47,000	800	50,500

Laboratory Results

Three sources of laboratory results, reflecting water quality conditions in the West Fork River Basin, have been considered in connection with the present investigation, namely: (a) results of the Ohio River Pollution Survey, published in House Document 266, 78th Congress, 1st Session, pages 375 to 380, and pages 402 and 403; (b) results of routine sampling and analysis conducted by personnel at various water purification plants treating West Fork River water continually at Weston and Clarksburg; and (c) results of stream sampling and analysis in the Weston and Clarksburg vicinities by the West Virginia Water Commission.

Ohio River Pollution Survey - Results of the Ohio Survey have already been published and are not reproduced in this report. These results form the principal basis on which conclusions in regard to useful flows have been drawn. Although the results were obtained seven years ago, the flows at the time samples were collected more nearly approached the flows that it is contemplated will be available following installation of the proposed reservoir at Brownsville. Pollution loads have not changed greatly.

Water Plant Results - The principal value of water plant analytical records is in estimating the effect of the proposed reservoir on alkalinity-acidity conditions, not only in the West Fork River Basin but in the lower Monongahela River Basin. The most substantial benefits derived from the project are due to the proposed discharge of alkaline water during low-flow periods into the Monongahela River, where acid discharges largely from mines but partly also from pickling operations in the steel industry, create substantial damage to navigation, water supply, and other uses.

The results at Weston, W. Va., have been taken to reflect the quality of water, from the standpoint of alkalinity, that will be stored in the proposed reservoir. The average methyl orange alkalinity at Weston during the period from 1943 to 1946 was 20.3 parts per million. However, if the individual results are weighted in accordance with the flow by giving principal weights to alkalinity results during periods of high flow, and relatively minor weight to results during very low flows, the weighted average alkalinity is 16.1 parts per million, reflecting the fact that flood flows are much less mineralized than flows during low-water periods. This is as might be expected.

At the time of the Ohio River Pollution Survey, it was estimated that the average alkalinity to methyl orange of natural waters in the Monongahela River Basin prior to any pollution from mines or other acid sources, was 10 parts per million. Compared to this, the weighted average quality at Weston was 16.1 parts per million, indicating that a portion of the more alkaline water in the basin comes from West Fork River. This is important, as it indicates that supplemental low flows will have a correspondingly increased value over the other developments in the Monongahela River Basin for purposes of improving acid conditions in the lower river. It also means that the amount of mining that can take place in West Fork River Basin before stream waters are irreparably damaged is greater than in the Monongahela River Basin as a whole.

State of West Virginia Results - The results obtained by the West Virginia Water Commission, and presented here through the courtesy of that commission, are summarized in Tables 5 and 6, Table 5 showing the results in the vicinity of Weston, W. Va., and Table 6 showing the results in the vicinity of Clarksburg, W. Va. As will be noted from the tables, these samples were collected during times of extremely low flow in all the streams of the West Fork River Basin, and therefore represent the most critical situation from the standpoint of objectionable organic pollution, principally domestic sewage. The chief conclusion drawn from these results is that a high degree of sewage treatment will be required in the basin, particularly in the absence of any supplemental flow.

It is noted that, at the time samples were collected, the flow at Weston was less than three second feet, and as far as the record is concerned, may have been zero, while at Clarksburg there is reported no discharge over the water supply dam. This means that in one case the flow in the river was practically, and in the other case was in fact, undiluted raw sewage. This conclusion is borne out by the results.

Experience elsewhere has indicated that where dilution water is entirely lacking, the discharge of sewage, no matter how efficiently treated, will not produce a stream of suitable condition for uses other than sewage disposal. There is therefore a need and consequent value for increased low flows in West Fork River regardless of the amount of treatment which is installed at Weston and Clarksburg.

Table 5 - East Fork River Investigation - Laboratory results from state of West Virginia.
Section, E. Va., and vicinity.

River	East Fork River above and in Section, E. Va.										East Fork Creek		State Creek
	State village	Section bridge	Section above dam	Section below dam	Section below dam	Section below dam	Section below dam	Section below dam	Section below dam	Section below dam	Section below dam	Section below dam	
Flow, c.f.s.	70.5	63.0	55.4	49.3	45.2	44.3	44.5	44.5	44.5	44.5	44.5	44.5	65.0
Temperature °C	12	13	17	23	25	26	26	26	26	26	26	26	26
Dissolved oxygen, p.p.m.	5.6	6.6	6.0	6.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Electrical oxygen demand, 5-day, 20°C, p.p.m.	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
California, mg per ml.	1	9	9	9	9	9	9	9	9	9	9	9	9

(a) Stage height below developed rating curve; lowest point on curve 3.0 c.f.s.

River	West Fork River at and near Clarksburg, W. Va.						
Sampling Station	Above W.W. Dam	Above Elk Cr.	Adamsen Br. below Elk Cr.	Below Adamsen	Above Hutter Fork	Hutter Fork	Ray
Miles to mouth of West Fork River	31.5	30.5	30	29	34	33.5	30
Date, 1946	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30
Flow, c.f.s.	(a)	(a)	(a)	(a)	4.0 est	4.0 est	4.0
Temperature °C	16	16	16	16	15	15	15
Dissolved oxygen, p.p.m.	7.5	8	8	8	5.8	6.2	6.2
Biochemical oxygen demand 5 day, 20°C, p.p.m.	0.1	10.5	11.8	16.5	1.6	0.8	0.8
pH	8.8	6.8	6.8	6.4	7.4	7.0	7.0
Alkalinity (B) p.p.m.							
Methyl orange	14.0	90.5	67.5	77.5	82.5	58.5	58.5
Phenolphthalein	-16	-11	-8	-18	-2.5	-5.0	-5.0
Chlorides	15	830	144	102	14	20	20
Hardness	348	620	376	380	352	336	336
Threshold odor number	12	222	100	250	3	4	4
Coliforms, MPN per ml.	0.1	3900	3900	3900	3.9	39	39

(a) Gage at Clarksburg water supply dam. No discharge over dam. City diverts 6 to 7 c.f.s.
 (b) Negative alkalinity indicates acidity.

and Va.			Elk Creek (Mile 30)				
Below Elk Cr.	Below Adanson	Above Butter Fork	Butter Fork	Raymond	V. Pike St.	Syn- nope St.	Mouth
30	29	34	33.5	32.5	31.8	30.6	30.0
Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30	Sept. 30
(a)	(a)	4.0 est.	4.0 est.	4.0 est.	4.0 est.	4.0 est.	4.0 est.
16	15	15	15	15	16	16	17
0	5.8	6.2	0.9	0.4	0	0	0
16.5	1.6	0.8	2.0	22.5	4.2	7.0	7.0
6.4	7.4	7.0	3.2	4.0	6.4	6.4	6.4
77.5	77.5	82.5	58.5	-62	-5.5	35.5	47.0
-18	-18	-2.5	-5.0	-114	-48	-10	-13
104	102	14	20	24	24	23	25
376	380	352	336	380	344	312	302
100	250	3	4	200	50	100	200
3900	3900	3.9	39	11	11	3900	3900

No discharge over dam. City diverts 6 to 7 c.f.s.

Low-Flow Frequency

A brief study has been made of the frequency of low monthly flows during the period of record. A summary of the results of the study is shown in Table 7. Consideration of the frequency of minimum flows is of considerable interest in connection with pollution studies, as an indication is obtained of the frequency with which objectionable conditions of various magnitudes have occurred in the past. In computing the low monthly flow frequencies, the lowest monthly flow only for each year of record is used. In the present instance, summer flows are particularly important and the lowest monthly flow occurring during the summer months of June through September for each year has been used.

Discussion

Comments resulting from the Ohio River Pollution Survey, in regard to the West Fork River, are of interest and are repeated here (H.R.266, 78-1, p.374):

"West Fork River - Clarksburg, W. Va., with a sewerage population equivalent of 29,000, is by far the largest source of pollution on this stream and its effect is clearly evident in the laboratory findings. The dissolved oxygen is reduced and the biochemical oxygen demand and coliform organisms are increased."

"In general the main stream is not highly acid except near the mouth, where many tributary creeks with low pH values discharge acid mine drainage. Two sewage treatment plants are located on this stream."

Policy

The consideration of pollution abatement benefits involves not only questions of the magnitude of the flows to be provided and the monetary benefits credited to those flows, but also questions dealing with other activities having as their objective the abatement of water pollution and the reclamation of polluted streams. The idea of crediting pollution abatement benefits assumes in essence that the streams will be cleaned up. Such an over-all activity requires not only

Table 7 - West Fork River Investigation +
 Low Summer (June through September)
 Monthly flow Frequency Based on Record

Frequency Once in	Low summer monthly mean discharge - cubic feet per second - West Fork River		
	Brownsville dam site, 102 sq. mi.	Weston W. Va. 123 sq.mi.	Clarksburg, W. Va. 384 sq.mi.

Unregulated

2 yrs	18	21	50
3 yrs.	6	8	18
5 yrs.	2.5	3.5	9
10 yrs.	1.5	2.5	8.5
Minimum	1.0	2.0	8

Regulated by West Fork River Reservoir

2 yrs.	130 *	130 *	200 *
3 yrs	130 *	130 *	200 *
5 yrs.	130	130	200
10 yrs.	104	104	160
Minimum	104	104	160

additional low flow, but treatment installations for sewage and industrial wastes and other measures leading to the correction or prevention of future pollution. Should there be little assurance of prompt construction of facilities to supplement flow regulation in reclaiming a stream for reasonable use, the crediting of pollution abatement benefits might be questioned.

With respect to municipal sewage pollution, the State of West Virginia is proceeding under statutory authority and rules and regulations, with the cities in the West Fork River Basin, to install treatment works. While the pollution abatement activities of the State and of the local communities in the past leave much to be desired, strengthened statutory authority is now available and the State has adopted an aggressive stream pollution abatement policy. There is assurance that proper sewage treatment plants will be installed in the not too distant future.

In regard to the question of acid mine drainage, the State of West Virginia has one of the best records, with regard to correcting acid pollution, of all the States involved with this problem. During the mine-sealing program conducted from 1933 to 1940, with the assistance of W.P.A. and under the sponsorship of the U.S. Public Health Service, an effort was made to reduce mine acid pollution by mine-sealing operations confined, first, to abandoned mines, and second, to such mines as could be sealed without excessive cost. It is estimated that this procedure, if carried to completion, would have reduced the acid mine drainage load in the Ohio River Basin by 53 per cent. However, the activity was discontinued with the termination of W.P.A., with only about fifty per cent of the job done, and the pollution load was reduced, in the Ohio Basin as a whole, only 26 per cent. However, in West Virginia, the mine-sealing program was enthusiastically welcomed and as a result, in that State, 87 per cent of the job was completed rather than 50 per cent in the Ohio River Basin as a whole. Acid mine drainage from West Virginia was reduced a total of 44 per cent out of a possible 51 per cent had the program been continued to completion.

To complete the acid pollution picture, it must be stated that, since the termination of the activity in 1939, there has been very little maintenance of the mine seals constructed under the program. It is probable that at the present time many of the seals then constructed are largely ineffective. However, the policy of the State of West Virginia is clear.

The State of West Virginia has proceeded, as have several other States, in an attempt to prevent further creation of acid through strip mining operations. This procedure has been in the form of a State law requiring that stripped material be returned to the excavation following strip mining operations. In West Virginia, a bond of \$500 per acre is required of companies engaged in strip mining operations, to insure that surface stripped material will be replaced. In certain instances the cost of replacing stripped material may be in excess of \$500 per acre. In such instances there is a financial advantage to a company's letting the bond go by default. This is largely conjecture, and the working out of the law to control strip mining operations will be watched with interest. However, again, the general policy of the State of West Virginia is clear in making a bona fide attempt to prevent further acid mine pollution.

Desirable Flows

There is need for additional flow during dry weather periods in West Fork River below Weston and below Clarksburg, to further improve the stream after at least partial treatment plants are installed at these two cities. The desirable flows in these two cases are limited, in that moderate increases in flow will accomplish, in conjunction with partial treatment, a stream quality suitable for all reasonable uses. Increases beyond these limited flows would have little if any local value of a tangible nature.

Superimposed on the flows required in West Fork River, are flows required on the main Monongahela River, not only for organic pollution abatement in that stream, but also to increase the flow of alkaline water contributed by the upper reaches of the West Fork River and thus decrease corrosion of towboats, barges, locks, equipment, industrial piping, and the like, as well as reduce the cost of treatment of public water supplies and industrial water supplies. Within the limits of the ability of West Fork River to supply increased flows, there is no limit to the amount of water which can be used to advantage and will have a monetary benefit in the Monongahela River.

There is one radical difference between the water requirements of the Monongahela River and those of the West Fork River. In connection with the flows in West Fork River, it is important that these flows be maintained at all times,

as even a relatively short period of failure to maintain the desired flows would result in damage to aquatic life built up during a period of improved stream conditions. On the Monongahela River, at least until the stream is vastly improved, the effect of increased flow will be to reduce corrosion, and failure to maintain increased flows for a few days only, but no lasting damage of benefits built up over a long period of time should result.

It can be concluded therefore that the flows designated as required in the case of the West Fork River should be maintained lest all benefits be lost, whereas the flows in the Monongahela River need not be so maintained, but can be supplied with a degree of latitude during low-water periods. The exact regulation as it affects the Monongahela River may be determined by other factors than either organic pollution or reduction in corrosion.

Desirable Flows Below Weston and Clarksburg - In estimating desirable flows below Weston and Clarksburg, it has been assumed that these two cities, as well as lesser communities on the river, will install partial treatment of all sewage, in this case taken as plain sedimentation or primary treatment. It has further been assumed that a desirable stream is one with a dissolved oxygen on any day of not less than 5 parts per million.

With the above assumptions, computations have been made using laboratory results of stream sampling programs, chiefly of 1940, as base data. These computations have been made in accordance with a publication entitled "The Rate of Atmospheric Reaeration of Sewage-Polluted Streams," by Sanitary Engineer Director H. W. Stricker, published as Reprint No. 1063 from the Public Health Reports. Without going into the details of these computations, it has been concluded that under present conditions the winter and summer flows, respectively, required below Weston are 50 c.f.s. and 112 c.f.s. The flows required below Clarksburg under present conditions, for winter and summer, are, respectively, 71 c.f.s. and 160 c.f.s. It is thought desirable to allow a certain factor of safety in the flows to be provided, and it is further thought desirable to make allowances to a limited degree for some future growth. Therefore, the flows concluded to be desirable are as follows:

<u>Location</u>	<u>Winter Flow</u>	<u>Summer Flow</u>
Weston, W. Va.	60 c.f.s	130 c.f.s.
Clerksburg, W.Va.	90 "	200 "

In general, the summer flows should be provided during July and August, and the winter flows provided from October through April. Intermediate flows should be provided during the spring months of May and June and the fall month of September. Actually the flows theoretically required during the winter for maintaining oxygen levels would be somewhat less during the extreme cold weather than is indicated. However, if flows are reduced to below the level indicated, there is a possibility of toxic substances creating a hazard to aquatic life, so that the reasonable winter minimum has been indicated.

Monetary Benefits

Benefits to pollution abatement by low-flow regulation as a supplement to partial sewage treatment are, as a rule, adequate to justify only a relatively small part of reservoir costs when only one source of pollution is benefited. However, if more than one source of pollution is benefited, the justifiable expenditure may be increased proportionately. In the case of the West Fork Reservoir, benefits are multiplied many times, as many successive sources of pollution are benefited, not only on West Fork River but also on the entire length of the Monongahela River and the entire length of the Ohio River. In addition to benefits to organic pollution abatement, there are also, in the case of the West Fork Reservoir and other reservoirs on the Monongahela River Basin, benefits due to dilution and to partial neutralization of acid mine water pollution. In the case of West Fork Reservoir, therefore, benefits to be realized from low-flow regulation may be expected to justify a substantial or even major portion of reservoir costs.

Benefit estimates to West Fork Reservoir, from organic pollution abatement and from acid control, are summarized as follows:

Organic Pollution AbatementEstimated
Annual Benefit

Below Weston, W. Va.	\$ 7,000
Below Clarksburg, W. Va.	43,000
Below Pittsburgh, Pa.	35,000
Below Cincinnati, Ohio	35,000
Total	<u>120,000</u>

Acid Control

Monongahela River above McKeesport, Pa.	214,000
Monongahela River below McKeesport, Pa.	75,000
Ohio River	41,000
Total	<u>330,000</u>

Total Annual Benefits

\$450,000

The benefits to acid control are of sufficient magnitude to be further detailed, as follows:

Nature of Acid Control BenefitAnnual Value

Domestic water supply quality (1)	\$ 58,000
Industrial water supply quality	65,000
Steamboat and barge corrosion	182,000
Power plant, quality and corrosion	12,000
River and harbor structures, corrosion	12,000
Floating plant (USED) corrosion	1,000
Total	<u>\$330,000</u>

(1) Does not include Weston and Clarksburg, W. Va.

In the case of benefits to pollution abatement below Weston and Clarksburg, W. Va., on West Fork River, monetary values have been based on recent cost estimates for pollution abatement in these two cities, as summarized and transmitted to this office in a letter of September 9, 1947, from J. B. Harrington, Director, Division of Sanitary Engineering, West Virginia State Department of Health. A copy of this letter is attached to this report as an appendix.

Estimates of monetary benefits from the proposed flow regulation due to acid control in the Monongahela River above McKeesport, in the Monongahela River below McKeesport, and in the

Ohio River, and benefits to pollution abatement in the Ohio River, have been taken from work done in connection with the Ohio River Pollution Survey. Very thorough investigations and computations were made at that time, and it was not felt necessary to repeat these computations, with more up-to-date information, for present purposes. It is probable that there would be very little change in the ultimate conclusions, and furthermore, such a project did not appear feasible inasmuch as twenty man-months of computations were involved, and time and personnel are not now available to repeat this work.

Weston and Clarksburg, W.Va., Benefits - Up-to-date estimates of cost for secondary treatment plants at Weston and Clarksburg, W. Va., are available through the courtesy of the State of West Virginia (see Appendix A). At the time of the Ohio River Pollution Survey already referred to, comprehensive studies were made of sewage treatment plant construction and operating costs. From these studies, ratios have been determined between the cost of secondary and primary treatment for cities of various sizes. These ratios have been used to estimate costs of primary treatment plants at Weston and Clarksburg, W. Va. Computations have been made of the difference in total annual charges for the two types of treatment at these two cities, as follows:

Weston, W. Va.				
Treatment	Estimated cost	Interest and amortization (1)	Operation and maintenance	Total annual charges
Primary	\$164,500	\$11,500	\$2,600	\$14,200
Secondary	235,000	16,500	4,700	21,200
Difference	70,500	4,900	2,100	7,000

(1) Cost x 0.07036 based on 3-1/2 per cent interest and 20-year life.

Clarksburg, W. Va.				
Treatment	Estimated cost	Interest and amortization (1)	Operation and maintenance	Total annual charges
Primary	969,340	68,200	9,600	77,800
Secondary	1,467,860	103,300	17,500	120,800
Difference	\$498,520	\$35,100	\$7,900	\$43,000

(1) Cost x 0.07036 based on 3-1/2 per cent interest and 20-year life.

In the event that Weston and Clarksburg, W. Va., install secondary sewage treatment plants prior to construction and operation of West Fork Reservoir, the increased low flow will result in benefits that it is believed will still fully justify the credit estimated. Secondary treatment will result in a higher standard of quality being maintained in West Fork River. The stream will be available for higher type purposes such as public water supply use, recreational use, and use by higher type aquatic life, all with less hazard to the public health. The benefit would represent the difference in cost between secondary and tertiary sewage treatment. At such time as substantial growth takes place in the valley, the stream can still be maintained in condition for all reasonable uses.

Pittsburgh, Pa., and Cincinnati, Ohio, Benefits - The U.S. Public Health Service report to the Pittsburgh, Pa., District Engineer on the Clarion River Investigation of February, 1945, discussed benefits from headwater reservoirs to pollution abatement below Pittsburgh, Pa., and Cincinnati, Ohio. Costs as presented in that report were taken from the earlier Ohio River Pollution Survey report which used prices based on average experience between 1928 and 1940 (H.R. 266, 78-1, pp. 151, 151, 200).

In these previous reports, benefits were estimated to be \$20,000 per year per 100 c.f.s. increase during the midsummer months of July and August (\$10,000 at Pittsburgh - \$10,000 at Cincinnati). Using a price index for 1947 of 175 per cent of the average 1928-1940 index, and an increase in summer flow of 200 c.f.s. produced by West Fork Reservoir, it is estimated that organic pollution abatement benefits in the Ohio River will be \$70,000 per year, or \$35,000 per year below Pittsburgh, Pa., and \$35,000 per year below Cincinnati, Ohio.

Acid Control Benefits - Estimates have been made of acid control benefits, using the detailed computations supporting similar estimates in the report of the Ohio River Pollution Survey as summarized on pages 196-200 of House Document 266, 78th Congress, 1st Session. Benefits estimated at that time have been increased for several reasons. An accurate estimate of all of the factors involved in these increases would involve extensive field investigations and office computations which have not been carried out. In the absence of results of such activities, increases to be considered quite conservative have been included in the present estimates. A brief discussion of the factors involved is of interest.

As has been mentioned, the water to be impounded by West Fork Reservoir is somewhat more alkaline than other upland waters of the Monongahela River Basin. Previous reservoir acid control benefits have been based on impoundments storing water with an alkalinity of 10 parts per million (methyl orange), while the weighted average of alkalinity determinations of West Fork River made by the Weston public water supply filter plant for the past 4 years is 16.1 parts per million. This might justify an increase of 61 per cent in benefit estimates.

There has undoubtedly been an increase in domestic and industrial water supply use of lower Monongahela River water, including cooling water use at steam power installations. No data have been collected on this factor, and no benefit increases have been included in the estimates.

There has undoubtedly been an increase in navigation activity on the Ohio and Monongahela Rivers corresponding to the increased industrial activity in the western Pennsylvania area. No data have been collected on this factor, and no increases in steamboat and barge corrosion benefits have been included in the estimates.

The opening of new mining areas and the increase in areas opened in existing mines have undoubtedly increased the mine acid discharge and thus increased the need for corrective measures. The Ohio Report (H.R.266, 78-1, p:197) estimated acid damages of \$2,071,000 in 1940 and \$2,630,000 in 1950. Interpolating, an increase in mine acid damages of 19 per cent for 1947 might therefore appear justified, with further increases during the life of the West Fork project. Carrying the matter of acid mine drainage damages to extremes, estimates of as high as \$15,000,000 per year have been placed on record. The damages and corresponding benefits set forth in this and previous U.S. Public Health Service reports are tangible, are based on careful field observations, and can be readily supported. The factor of increased damage has not been used in this report.

The price index of 175, representing present construction costs as compared with an index of 100 on which the pollution abatement benefits were based, has been mentioned. A somewhat lesser increase has been used (150 per cent) in the case of acid control benefits.

In previous estimates of flow regulation benefits from western Pennsylvania reservoirs, projects in the Allegheny River Basin were lumped with projects in the Monongahela River Basin (H.R.266, 78-1, p.200). However, acid control benefits in the Allegheny River Basin are lower (Clarion River Investigation, U.S.P.H.S., February, 1945, p.17) than those in the Monongahela River Basin. The West Fork Project can therefore be expected to have greater unit benefits than average benefits for the western Pennsylvania area.

Offsetting some of the increases enumerated, there has been some damage reduction through the increased use of acid-resisting metals and paints in replacements in the acid stream areas.

Benefits to West Fork Reservoir, excluding local benefits at Weston and Clarksburg, W. Va., total \$400,000 per year or \$3.05 per year per acre-foot of the 131,000 acre-foot summer conservation storage. Should the percentage increases discussed be applied to proper parts of the per acre-foot benefit figure given in the Ohio River Report (H.R.266, 78-1, p.200), a per acre value of in excess of \$5.00 per acre-foot per year would result, the exact figure depending on the detailed method of computation adopted. It is believed that the benefit estimates presented are conservative and reasonable.

Intangible Benefits - In addition to the benefits for which estimates are presented, there are numerous benefits, equally real and justifying expenditures of magnitude, but which, because of their nature or other limitation, cannot be monetarily evaluated. These benefits, referred to as intangible, include benefits to agricultural use including stock watering, benefits to aquatic and wild life and to recreation, and indeterminate values to the public health.

APPENDIXState of West Virginia Department of HealthLetter of September 9, 1947Pollution Abatement Activities and Costs.

(Copy)

26.

STATE OF WEST VIRGINIA
DEPARTMENT OF HEALTH
CHARLESTON 5

September 9, 1947

Mr. M. LeBosquet, Jr.
Sr. Sanitary Engineer
U.S. Public Health Service
Water & Sanitation Investigations
East Third & Kilgour Streets
Cincinnati 2, Ohio

Dear Mr. LeBosquet:

With reference to our telephone conversation of September 5, 1947 regarding the pollution of West Fork River below Weston, West Virginia, I wish to advise you as follows.

Prior to the war a very extensive mine-sealing program was carried out through the Works Progress Administration, the United States Public Health Service and the State Health Department. This project was very popular with the public and according to investigations improved the condition of the stream materially. The savings in the cost of operating water plants, power plants and industrial plants has been substantial.

Unfortunately the project was discontinued during the war and is still at a standstill because of labor conditions, lack of funds, and the shortage of materials.

Strip mining has been very active on the watershed of the West Fork River and in some instances has caused considerable concern to the residents. The water supply of Shinnston has been seriously damaged by acid wastes from strip mining operations and damage suits have been filed against the operating companies.

The following summary of sewage treatment estimates on the West Fork River and Monongahela River are submitted for your information. Only Weston and Clarksburg are based on engineering reports. Morgantown's is based on a preliminary study while the others are based on scaled distances for interceptor costs and office estimates on treatment. The later treatment costs are also based on general field knowledge, topography and population possibilities. All treatment is estimated as primary excepting Clarksburg and Weston.

West Fork River Pollution

Sept. 9, 1947

MUNICIPALITY POPULATION		COSTS		
		Interceptor	Treatment	Total
Clarksburg	30,579	1,507,939	1,467,860	2,975,799
Fairmont	23,105	3,000,000	400,000	3,400,000
Morgantown	16,655	700,000	350,000	1,050,000
Rivesville	1,552	100,000	40,000	140,000
Sabraton		Included with Morgantown		
Shinnston	2,817	150,000	60,000	210,000
Star City	1,175	Included with Morgantown		
Westover	1,752	200,000	60,000	260,000
Weston	8,268	220,000	235,000	457,000

It is our opinion that storage reservoirs on the West Fork River would be very beneficial to water supplies, would improve fish life and recreational conditions and would attract industries to this valley. It is of interest to note that E. I. duPont de Nemours Company located at Morgantown, West Virginia, chiefly because of the assured flow of water from the Tygart Valley Dam.

Very truly yours,

STATE DEPARTMENT OF HEALTH

Division of Sanitary Engineering

By J. B. HARRINGTON
Director